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Forum

Taxonomy

New Species Described From Photographs: Yes? No? Sometimes? A Fierce Debate and a New Declaration of the ICZN

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Abstract

The option of describing new taxa using photographs as proxies for lost or escaped ('unpreserved') type specimens has been rarely used but is now undergoing renewed scrutiny as taxonomists are increasingly equipped to capture descriptive information prior to capturing and preserving type specimens. We here provide a historical perspective on this practice from both nomenclatural and practical points of view, culminating in a summary and discussion of a new Declaration of the *International Commission of Zoological Nomenclature* containing recommendations about descriptions without preserved specimens. We conclude that although descriptions using photographs as proxy types are *Code*-compliant and occasionally justified, the conditions under which such descriptions are justified are likely to remain relatively rare. Increasing restrictions on specimen collecting, which we deplore because of the centrality of collecting and collections to all of biodiversity science, could lead to more 'proxy type' descriptions in those taxa in which photographs can provide sufficient information for descriptions, but we predict that such cases will remain infrequent exceptions.

Key words: nomenclature, photograph, proxy type, taxonomy

Most of us were taught in our academic infancy that the description of a new species requires a published description and a designated type, and most entomologists involved with the discovery and description of new species realize that many other criteria should be met in order to justify a species description. We do not all agree on exactly where the bar should be set, but there is general agreement that new species must at a minimum be justified in the context of related and similar species and must be diagnosable. Descriptions of species that cannot be subsequently recognized are detrimental, and descriptions of species outside the context of the rest of their clade are usually of little use. The requirements for a published description and a designated type are embedded in the *International Code of Zoological Nomenclature* (ICZN 1999) and are governed by specific rules; the criteria for justified species descriptions and 'good' taxonomy are matters of taxonomic judgement.

While new species have occasionally been described and formally named without a preserved type specimen, a recent paper by Marshall and Evenhuis (2015) explicitly discussing and executing such a procedure sparked a heated worldwide debate on social media and in a still growing number of formal publications. This discussion has sometimes drifted into emotional or uninformed arguments and is becoming increasingly repetitive but demonstrates that the issue is a controversial one. The coincidence of the launch of *Insect Systematics and Diversity* and the publication of a Declaration by the *International Commission on Zoological Nomenclature* (ICZN) in March 2017 on descriptions without preserved types (ICZN 2017) led to the drafting of this paper. Our aim is to calm the waves by giving a historical perspective of the issue, clarifying the rules of nomenclature, and emphasizing the centrality of taxonomic judgment and good practice.

The Rules: What Does the Zoological Code Say?

The *International Code of Zoological Nomenclature* ('the *Code*', ICZN 1999) is a set of rules and guidelines designed to ensure that the names used to communicate about biodiversity are unique, universal, and stable. The requirements that must be met to add a formal species name to the language of science are, critically, governed by explicit rules that all taxonomists must abide by, whether or not their new descriptions meet the subjective criteria of good science. And one of the best known of those requirements is that all new

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species names must be linked to an individual or voucher that serves as the objective standard for the species name. Normally that individual will be a preserved specimen such as a pinned insect or slide mount, but the *Code* does allow for exceptions such as the loss or destruction of the type specimen before or after description. The loss of types after description is common. For example, the original types of over 10% of all snake species are missing or lost (Wallach and Jones 1994) and ca. 30–40% of all accepted nemertean names lack a preserved type specimen (Crandall et al. 2001). The *Code* recognizes that such secondarily typeless species only occasionally cause problems and provides for the resolution of problems that do arise through the designation of replacement types (neotypes). The loss of types prior to the publication of a description is less common, and is the issue at hand. Despite claims to the contrary (e.g., Landry 2005, Timm et al. 2005, Santos et al. 2016, Garraffoni and Freitas 2017), the *Code* explicitly allows the naming of a species after the type is lost or destroyed, as explained below. The description of a new species using a photograph as a proxy for a lost type is thus in compliance with the *Code*.

Some of the participants in the proxy type debate object to this provision in the *Code*, describing it as a loophole, complaining that it was written before the modern era of digital photography, and calling for it to be changed. It is important to understand that a change in the *Code* to disallow the use of photographs as proxies for lost types would not change the underlying taxonomy. The processes of discovery and description of species, which are matters of taxonomic judgment rather than rules, would remain the same. But if the *Code* were changed to disallow descriptions based on lost types then new species represented only by photographic (or other) records of unpreserved specimens would have to be named or referred to under a system independent of the *Code* and would thus lack universality and stability. Alternatively, such new discoveries could be left without any sort of name, unnecessarily hampering communication and clarity. The nomenclatural aspect of this controversy is thus just about whether and what name to apply to a species, not an issue of the reality, legitimacy, or value of a species discovery and description. Scientific quality is not governed by the *Code*. One of the explicit underlying principles upon which the *Code* is based—in fact the first principle listed in the introduction to the *Code*—is that it 'refrains from infringing on taxonomic judgement, which must not be made subject to regulation or restraint'. Taxonomic judgement is an important issue, and criteria for distinguishing 'good' taxonomy from 'bad' taxonomy are of fundamental interest to every taxonomist, editor, and reviewer. But these criteria vary widely from taxon to taxon and from case to case. In most circumstances, the choice to describe a taxon on the basis of a lost or seriously damaged type specimen would stand out as poor taxonomic judgement, but under some exceptional circumstances it is justified and cases of 'typeless' descriptions (good and bad!) have periodically appeared for decades. We here present a short history of these cases before going on to examine the more recent controversy over 'proxy types'.

A Short History of Descriptions Based on Illustrations or Without Preserved Type Material

The naming and description of species based on previously published illustrations was a common practice in the early time of Linnaean taxonomy. When Linnaeus compiled his *Systema Naturae*, he listed all known species whether he had seen specimens or not. His type series consist of all the specimens depicted or described in the cited references, plus specimens he had in his collection at the time of the description, if any (*Code* Art. 72.4.1). If he had none, then only the specimens from the references count for the type series. Article 72.4.1 allows for this not uncommon situation and is explained further by Art. 72.5.6: 'In the case of a nominal species-group taxon based on an illustration or description, or on a bibliographic reference to an illustration or description, the name-bearing type is the specimen or specimens illustrated or described (and not the illustration or description itself).' Article 73.1.4. says essentially the same thing in a different context.

When all the species from previous literature were classified in the Linnaean binominal style, new species descriptions became almost exclusively linked to preserved specimens, except for groups in which specimen preservation poses a problem, such as protists (Duszynski 1999, Aescht 2008, Lainson et al. 2008, Lahr et al. 2012), ctenophores (Matsumoto 1988), or meiofaunal slugs (of which at least the extracted DNA could serve as the holotype with the rest of the specimen being destroyed in the extraction process; Jörger and Schödl 2013). In such groups, species descriptions without preserved type material have always been common, unavoidably so. A binding rule requiring preserved type specimens would exclude those branches of zoology from the zoological *Code*. But what about 'preservable' taxa, such as insects and vertebrates? Here too, there is a history of descriptions without preserved material, but it is a much shorter one (Table 1).

Type Specimens Not Preserved at Time of Description

There are numerous historical examples of species described without original specimens having been directly studied. One such example is Billberg's ichthyological paper from 1833, in which he described three new species of pipefish (now all junior synonyms) from drawings that the soldier and artist Johan Wilhelm Palmstruch had made 30 yr before from living animals (Kullander 2016). This is as close as it gets to photo-based descriptions in times when photography was yet to be invented, but such descriptions of species by authors without first-hand knowledge of the type specimens are now explicitly discouraged by the Code: 'An author should designate as holotype a specimen actually studied by him or her, not a specimen known to the author only from descriptions or illustrations in the literature.' (ICZN 1999, Recommend. 73B).

While photo-based descriptions of preservable taxa have appeared in the scientific literature more frequently since the advent of accessible digital photography, such examples are still extremely rare (Table 1) compared with the 17–20,000 new species described every year (IISE 2011). Such descriptions without preserved type specimens are a continuum (Table 1) including:

- taxa described from living, captured specimens that mostly were later preserved (Delacour and Labouille 1924, Nicolai 1972, Brown 1987, Meier et al. 1987, Böhme and Ziegler 1997, Zimmermann et al. 1997, Tomey 2000, Kappeler et al. 2005, Andriantompohavana et al. 2006);
- photographed specimen with parts preserved (e.g., feathers, blood, or tissue samples) (Smith et al. 1991; Olsen et al. 2002; Thalmann and Geissmann 2005; Athreya 2006; Andriantompohavana et al. 2006, 2007; Louis et al. 2006, 2008; Zaramody et al. 2006; Olivieri et al. 2007; Lei et al. 2008, 2015; Radespiel et al. 2008, 2012; Gentile and Snell 2009; Barrera et al. 2010; Frasier et al. 2016; Hotaling et al. 2016; Andriaholinirina et al. 2017; Craul et al. 2017);
- studied and preserved specimen that got lost between description and publication of the description (Dyne and Jamieson 2004, Kieneke et al. 2015);

Table 1. Species of preservable taxa, described in the 20th and 21st centuries without preserved name-bearing whole-body type specimen at the time of description, in chronological order. Bold: species the authors of which did not intend or were unable to preserve physical types (specimens or parts). The examples of this group are likely to be complete. The examples of types consisting of minor physical parts, such as fur, DNA, or blood samples, are comprehensive but certainly not complete

Taxon	Types	History	Current status
Leptoplana mediterranea Bock 1913 (Platyhelminthes: Polycladida: Leptoplanidae)	Described from drawings published by Lang (1884).	Conditionally described as form of *Leptoplana tremellaris* from the figures by Lang (1884). Nomenclatural availability confirmed and elevated to species level by Gammoudi et al. (2012) who misstated the type locality though.	Valid (Gammoudi et al. 2012).
Lophura imperialis Delacour and Jabouille 1924 (Aves: Galliformes: Phasianidae)	Types specimen 'in Coll. J. Delacour', later specified as alive 'in my aviary at Clères' (Delacour and Jabouille 1925).	The female syntype was preserved in the Muséum National d'Histoire Naturelle in Paris upon its death in 1927 and was available for morphological and genetic studies; the male syntype was lost during World War II (Hennache et al. 2003).	Identified as a hybrid (Hennache et al. 2003).
Hypochera lorenzi Nicolai 1972 (Aves: Passeriformes: Viduidae)	Holotype specimen alive, in the institute's possession, later preserved in a museum collection (Elzen 2010).	Synonymized by Payne (1976) with *H. wilsoni* which seems to be more variable than Nicolas considered. The type was preserved in the Bonn museum by 1982 or earlier (Payne 1982).	Synonymized (Elzen 2010).
Hoplolatilus geo Fricke and Kacher 1982 **(Pisces: Perciformes: Malacanthidae)**	Photographs, no preserved parts; no types designated	Described from photographs and observations with a submersible at 80–116 m depth. Collection of specimens impossible.	Valid (Earle and Pyle 1997).
Malurus campbelli Schodde and Weatherly 1983 **(Aves: Passeriformes: Maluridae)**	Holotype designated from photograph, drawing from photograph published, archival prints of photographs deposited in museum collections.	Specimens were netted, photographed, and banded but not collected. Later a specimen could be preserved (Schodde 1984). Currently in the genus *Chenorhamphus* Oustalet (Driskell et al. 2011).	Valid (Driskell et al. 2011).
Pytilia melba flavicaudata Welch et al. 1986 **(Aves: Passeriformes: Estrildidae)**	Holotype designated from photograph; no preserved parts. Photograph in museum collection, not published.	Described in a self-published work on the basis of a photograph of the holotype and two paratypes; photographs deposited in the Natural History Museum London. Redescribed by Welch and Welch (1988), still as 'subsp. nov.'. Here the authors consider the three additional males mentioned in the original descriptions as paratypes, photos of which are in the same museum collection. Payne (1989) suggests to consider the subspecies 'invalid until specimens have been collected' which is not supported by the *Code*. Later, Welch and Welch (1992) note that 'The taxonomic status of the birds in Djibouti remains unclear.'	Status currently unclear (color variant or subspecies) (Payne 2010).
Hapalemur aureus Meier et al. 1987 (Mammalia: Primates: Lemuridae)	Holotype captured, photographed, measured, catalogued, and kept alive in captivity in a zoo. Karyotype described. Intent to deposit the holotype specimen after death in collection.	No explicit reason for not preserving the holotype is given, but it was regarded as highly endangered. Current status of the holotype unknown to us. Fausser et al. (2002) studied five specimens from the zoo where the holotype was kept but did not mention that specimen.	Valid (Wright and Tan 2016).
Parosphromenus allani Brown 1987 and *Parasphromenus harveyi* Brown 1987 (Pisces: Perciformes: Osphronemidae)	Living specimens. Photographs published, but 'Neither of the specimens in these photographs are the holotypes for the new species.' Besides saying what is not the holotype, the author did not clarify which specimens are the holotypes. Type material now preserved in a museum collection.	Preliminary description from living aquarium specimens; intended full description was never published. Type depository not published. As the type material of both species was preserved, it could be revised and lectotypes designated (Kottelat and Ng 2005).	Valid (Kottelat and Ng 2005).

Table 1. *Continued*

Taxon	Types	History	Current status
Lonchura spectabilis sepikensis Jonkers and Roersma 1990 **(Aves: Passeriformes: Estrildidae)**	Holotype designated from photograph, photograph deposited in museum. No preserved parts.	Payne (2010: 376) 'provisionally included' it in (= synonymized it with) another subspecies.	Unresolved.
Laniarius liberatus Smith et al. 1991 (Aves: Passeriformes: Malaconotidae)	Holotype designated, photographed, specimen released. Preserved parts: DNA, three drops of dry blood on a piece of paper (kept deep frozen), two tubes of blood (in EDTA buffer), and moulted feathers mounted on a cardboard	This is the first case of a bird holotype singleton that was deliberately released (after description, after a year in captivity, and 175 km from its place of capture) which caused wide discussion and criticism (see Collar 1999). The preserved blood samples allowed reassessment of the species within a molecular phylogenetic analysis of the genus *Laniarius*, resulting in the synonymization of *L. liberatus* with *L. erlangeri* (Nguembock et al. 2008).	Synonymized (Nguembock et al. 2008).
Cryptophidion annamense Wallach and Jones 1994 **(Squamata: Serpentes)**	Three color slides taken in 1968. Holotype designated from photographs. No preserved parts.	The detailed description provided Pauwels and Meirte (1996) with the opportunity for a detailed critique, resulting in the synonymization of the species. This was strongly rebutted by the authors (Wallach and Jones 1996) and one of the referees of the paper (Lazell 1996). Treated as valid genus in the family Colubridae by Zaher et al. (2009) and as a valid species by Das (2015), but, e.g., Wogan et al. (2012) accepted Pauwels and Meirte's syonymy.	Unresolved.
Varanus melinus Böhme and Ziegler 1997 (Squamata: Varanidae)	Living, catalogued specimens. Photographs published. Holotype and one paratype now preserved in a museum collection.	Four specimens were imported from Obi Island, Indonesia, to Germany. One of them was obtained for the vivarium of the Museum Koenig in Bonn and designated as the holotype. The paratypes were promised to the same Museum after their death, but only one of them ended up preserved in the Bonn collection (Böhme 2014). Böhme now considers it a mistake having used living specimens as types that are in the possession of other people and not guaranteed to be preserved in the designated repository (Böhme 2014).	Valid (Böhme 2014).
Microcebus ravelobensis Zimmermann et al. 1997 (Mammalia: Primates: Cheirogaleidae)	Holotype and paratype were living, catalogued specimens, maintained at a zoo and intended for preservation in a public collection.	The species was described by Zimmermann et al. (1998), but is actually available from a previously published abstract (Zimmermann et al. 1997). While holo- and paratype were intended for preservation in a public collection, they were not preserved after they died and are lost (Rasoloarison et al. 2000). No preserved parts of the type series are documented. Rasoloarison et al. (2000) designated a preserved specimen as the neotype.	Valid (Yoder et al. 2016).
Bebearia banksi Hecq and Larsen 1998 **(Insecta: Lepidoptera: Nymphalidae)**	Holotype designated from videotape, of which photographs are published. No physical evidence preserved.	Re-interpreted and synonymized by the junior author seven years later (Larsen 2005).	Synonymized (Larsen 2005).
Badis badis bengalensis Tomey 2000 (Pisces: Perciformes: Badidae)	Living specimens, types designated on published photographs. Types intended to be preserved in a museum collection.	'Animals in the type series live under my care. I intend to deposit them after death in NNM, Leiden'. This had not yet happened when the family Badidae was revised and the subspecies synonymized 2 yr later (Kullander and Britz 2002), but the intention of the author to deposit type specimens according to Art. 16.4.2. was clearly stated, making the name available.	Synonymized (Kullander and Britz 2002).

Table 1. *Continued*

Taxon	Types	History	Current status
Ninox sumbaensis Olsen et al. 2002 (Aves: Strigiformes: Strigidae)	Holotype 'was collected [shot] by a local bird hunter. The body was left with villagers on Sumba. Feathers and photographs are lodged [and properly accessioned] at Heidelberg University'.	A reason why the body was not preserved for science was not given. According to Peterson (2014) 'the specimen documentation of its phenotype is only very fragmentary, so comparisons with other, similar taxa will forever be difficult.' However, in the original description the cytochrome b gene was sequenced, obtained from the collected feathers, and the sequence compared to that of related species.	Valid (Madika et al. 2011, Peterson 2014).
***Diplotrema glareaphila* Dyne and Jamieson, 2004 (Annelida: Oligochaeta: Acanthodrilidae)**	Holotype and paratypes designated and represented by drawings. Lodgement of types unknown at time of description.	Based on an unpublished description and illustrations by the senior author. The types got lost before publication of the description. According to the Earthworm Species database (see Csuzdi 2012) the name is unavailable, not complying with Art. 16.4 (ICZN 1999). This is incorrect since holotype and paratypes were designated, but were, for all intents and purposes, no longer extant so that Art. 16.4.2 (intent to deposit) does not apply.	Valid.
Lophocebus kipunji Ehardt et al. **in** Jones et al. 2005 **(Mammalia: Primates: Cercopithecidae)**	Holotype and paratype designated from photographs, no preserved parts.	'The number of individuals in each of the two populations of this species is undoubtedly very small; no live individual shouls be collected at this time to serve as the holotype. The Rungwe-Livingstone pupulation is designated the source population for physical specimens in support of the holotype.' (Jones et al. 2005). When a specimen became available for study a year after the description, the species was transferred into its own, new genus, *Rungwecebus* Davenport et al. 2006, and a variety of research initiated.	Valid (Davenport et al. 2016).
Macaca munzala Sinha et al. 2005 **(Mammalia: Primates: Cercopithecidae)**	Holotype and paratypes designated from photographs, No preserved parts.	No specimen preserved because of ethical considerations. The authors intended to collect paratypes post-description and deposit them in collections. However, paratypes cannot be designated after the description is published. In the year of the published description, a specimen became available, killed by local people in self-defence, which was then described in detail and correctly called a 'voucher specimen' (Mishra and Sinha 2008). Biswas et al. (2011) did not consider *M. munzala* a distinct species but could not resolve its taxonomic status.	Unresolved (Biswas et al. 2011), but considered valid by Sinha (2016).
Microcebus lehilahytsara Roos and Kappeler in Kappeler et al. 2005 (Mammalia: Primates: Cheirogaleidae)	Six syntypes alive at zoo, DNA preserved, measured, photographed.	No intention for deposition of deceased type specimens stated. Fate of the specimens unknown to us.	Valid (Yoder et al. 2016).
Avahi cleesei Thalmann and Geissmann 2005 (Mammalia: Primates: Indriidae)	Holotype captured, photographed, videographed, audiotaped, and released. Hair samples preserved in museum collection.	The species is considered endangered. The authors did not collect a specimen for ethical reasons.	Valid (Thalmann and Baden 2016), but questioned by Zaramody et al. (2006).
***Cebus queirozi* Mendes Pontes and Malta in** Mendes Pontes et al. 2006 **(Mammalia: Primates: Cebidae)**	Holotype and paratype designated. Holotype captured, measured and photographed, then released without preservation of parts. Paratype photographed.	Simultaneously, de Oliveira and Langguth (2006) re-establish *Simia flava* Schreber, 1774, and designate a neotype. In a note added in proof, they state the identity of *C. queirozi* with Schreber's species, but explicitly do not declare it a junior synonym because they erroneously consider *C. queirozi* unavailable as it is described without a preserved type specimen. Rylands and Mittermeier (2009) finally synonymize the two names.	Synonymized (Rylands and Mittermeier 2009).

Table 1. *Continued*

Taxon	Types	History	Current status
Liocichla bugunorum Athreya 2006 (Aves: Passeriformes: Leiothrichidae)	Holotype captured, photographed, measured, and released. Some feathers deposited in museum collection.	According to Peterson (2014) 'Conversations with the author of the description indicate that no specimen was collected because government regulations made collection of a more complete specimen impossible at the time.'	Valid (Peterson 2014).
Lepilemur ahmansoni, Lepilemur fleuretae, Lepilemur grewcocki, Lepilemur hubbardi, Lepilemur jamesi, Lepilemur milanoii, Lepilemur seali, Lepilemur tymerlachsoni, Lepilemur wrighti Louis et al. 2006 (Mammalia: Primates: Lepilemuridae)	Syntypes captured, photographed, measured, blood samples taken and preserved, and specimens released. Two syntypes of *L. milanoii* held alive in a zoo, microchip tagged and ear biopsies sampled.	'Due to the inability to maintain sportive lemurs as long-term live vouchers in captivity, the type series [...] are represented by whole blood samples from free-ranging individuals along with a database containing all field data, accessioned sequence data, and photographs' (Louis et al. 2006). Since photos and data cannot be part of a type series, the type series consist of the specimen pictured in these photographs and physically represented by the blood samples. – Hoffmann et al. (2009) emended *L. ahmansoni* to *L. ahmansonorum*, *L. grewcocki* to *L. grewcockorum*, *L. hubbardi* to *L. hubbardorum*, *L. jamesi* to *L. jamesorum*, *L. tymerlachsoni* to *L. tymerlachsonorum*, and *L. wrighti* to *L. wrightae* because of grammatically wrong endings according to the stated dedications. However, Article 32.5.1. (ICZN 1999) states that incorrect latinization must not be corrected, and the original spellings be maintained.	Valid (Wilmet et al. 2014).
Microcebus mamiratra Andriantompohavana et al. 2006 (Mammalia: Primates: Cheirogaleidae)	Holotype captured, photographed, measured, microchip tagged, and kept alive in captivity in a zoo. Tissue samples preserved.	Current status of the holotype unknown to us.	Valid (Louis and Lei 2016, Yoder et al. 2016).
Microcebus mittermeieri, Microcebus jollyae, Microcebus simmonsi Louis et al. 2006 (Mammalis: Primates: Cheirogaleidae)	Holotypes alive in zoo, microchip tagged. Ear biopsies and blood preserved.	Current status of the holotypes unknown to us.	Valid (Yoder et al. 2016).
Avahi peyrierasi, Avahi meridionalis, Avahi meridionalis ramanantsoavani Zaramody et al. 2006 (Mammalia: Primates: Indriidae)	Holotypes captured, measured, skin biopsies taken and preserved, specimens released.	No explicit reason for not preserving the full holotype is given.	Valid; *A. ramanantsoavani* considered distinct species (Louis 2016d).
Avahi betsileo Andriantompohavana et al. 2007 (Mammalia: Primates: Indriidae)	Holotype captured, photographed, measured, blood sample taken and preserved, and specimen released. Total genomic DNA for three paratypes preserved.	No explicit reason for not preserving the full holotype is given, but 'the highly folivorous dietary requirements of this group of lemurs currently precludes any attempts to curate "live vouchers"' (Andriantomopohavana et al. 2007).	Valid (Louis 2016a).
Microcebus bongolavensis, Microcebus danfossi, Microcebus lokobensis Olivieri et al. 2007 (Mammalia: Primates: Cheirogaleidae)	Holotypes captured, photographed, measured, ear biopsies and hair samples taken, specimens released.	No full specimens were preserved because the novelty of the species was only discovered later in the lab. Very late in the production of the paper, specimens were preserved of each of the new species and included as paratypes while it was too late to use them as the holotypes (U. Radespiel, pers. comm., 2017). Facilitated by preserved genetic material, *M. lokobensis* was synonymized with M. *mamiratra* Andriantompohavana et al., 2006 as a consequence of parallel descriptions (Louis et al. 2008).	*M. bongolavensis* and *M. danfossi* valid; *M. lokobensis* synonymized (Yoder et al. 2016).

Table 1. *Continued*

Taxon	Types	History	Current status
Dulichiella terminos Lowry and Springthorpe 2007 (**Crustacea: Amphipida: Melitidae**)	Holotype designated and species described from figures in Ledoyer (1986) who had misidentified the species as *D. appendiculata*; 'whereabouts of specimen not known, probably no longer extant'.	Ledoyer's (1986) detailed description and illustrations allowed Lowry and Springthorpe (2007) to include and describe the species as new in their revision of the genus.	Valid (Paz-Ríos and Adrisson 2014).
Avahi mooreorum, *Lepilemur scottorum* Lei et al. 2008 (Mammalia: Primates: Indriidae and Lepilemuridae)	Syntypes captured, photographed, measured, blood sample taken and preserved, microchip tagged, and specimen released.	No explicit reason for not preserving the full holotype is given, but 'the highly folivorous dietary requirements of these groups of lemurs currently precludes any attempts to curate "live vouchers"' (Lei et al. 2008).	Valid (Louis 2016b,c).
Microcebus margotmarshae, *Microcebus arnholdi* Louis et al. 2008 (Mammalia: Primates: Cheirogaleidae)	Holotypes captured, measured, ear biopsies and blood samples taken, microchip tagged, specimens released. Total genomic DNA preserved.	No explicit reason for not preserving complete holotypes is given, but the threatened status of lemurs was mentioned in the introduction. According to the descriptions, photos exist for the paratypes, but were not mentioned for the holotypes. The webpage for the Appendix with more detailed information was inaccessible [29 July 2017].	Valid (Yoder et al. 2016).
Microcebus macarthurii Radespiel et al. 2008 (Mammalia: Primates: Cheirogaleidae)	Holotype captured, photographed, measured, ear biopsies and hair samples taken, and specimen released.	'The animal itself was released [...] since its taxonomic distinctiveness was not recognized at the time of capture' (U. Radespiel, pers.comm. 2017).	Valid (Yoder et al. 2016).
Conolophus marthae Gentile and Snell 2009 (Squamata: Iguanidae)	Holotype captured, branded, transpondered, photographed, measured, and released. Blood sample preserved in museum collection. Intent to deposit the holotype specimen after death in collection.	The species was discovered in 1986 and identified as distinct and studied in depth by Tzika et al. (2008) and Gentile et al. (2009). It was informally named 'rosada' before it was finally named in a *Code*-compliant way by Gentile and Snell (2009). Despite preserved physical evidence (blood), the release of the holotype has drawn harsh criticism (Nemésio 2009) but was equally strongly defended by Donegan (2009). Frick (2010) explains that the measures taken by the authors to relocate the specimen after its death do not guarantee that the specimen can be found.	Valid (Onorati et al. 2017).
Grallaria fenwickorum Barrera and Bartels in Barrera et al. 2010 (Aves: Passeriformes: Grallariidae)	Specimen captured, photographed, and released. Some feathers were preserved. Two preserved complete specimens were photographed in the description, but not designated types because they were collected lacking a relevant permit.	Peterson (2013, 2014) considered the preserved feathers undiagnostic. The species was described simultaneously, but published slightly later, by Carantón-Ayala and Certuche-Cubillos (2010), the discoverer of the new species, with the preserved specimens as types. This story is full of politics, paperwork issues, problematic behaviour, financial incentives, rivalry, etc. (Regalado 2011, Fundación ProAves de Colombia 2013) and as a whole does not reflect well on the taxonomic and conservation community. Peterson (2013) applied to the ICZN to designate one of the preserved specimens as the neotype and Fundación ProAves (2013) added alternative proposals. The results of the ICZN's vote are yet to be published.	Valid.
Forpus flavicollis Bertagnolio and Racheli 2010 (**Aves: Psittaciformes: Psittacidae**)	31 syntypes designated on a photograph (of the internet). No preserved parts.	Donegan et al. (2011) considered the syntypes dyed specimens of a parrotlet common in the area and synonymized the species.	Synoymized (Donegan et al. 2011).

Table 1. *Continued*

Taxon	Types	History	Current status
Microcebus gerpi Radespiel et al. 2012 (Mammalia: Primates: Cheirogaleidae)	Holotype captured, measured, photographed, hair and tissue samples taken, and specimen released.	'The animal itself was released [...] since its taxonomic distinctiveness was not recognized at the time of capture' (Radespiel et al. 2012).	Valid (Yoder et al. 2016).
Strix omanensis Robb et al. 2013 **(Aves: Strigiformes: Strigidae)**	Holotype designated from photo. No parts preserved.	Robb et al. (2013) discovered that *Strix butleri* comprised two species, compared that battered type of this species with the photographs of a specimen from Oman and decided that the latter is a new species. Kirwan et al (2015), also studying the *S. butleri* type, assumed the synonymy with *S. omanensis*, which was confirmed by Robb et al. (2016) when they had captured a specimen and could study DNA.	Synonymized.
Macaca leucogenys Li et al. 2015 **(Mammalia: Primates: Cercopithecidae)**	Holotype and two paratypes designated from camera trap photographs. No parts preserved.	Li et al. (2015) state that 'Due to ethical concerns regarding killing wild primates, we did not obtain a voucher specimen for the proposed new species'. In the year of the description, skins of the species from specimens killed by local dogs became available and are now preserved in a museum collection (Fan et al. 2017), and soon after a 'specimen' was collected for studying the mitochondrial genome (Hou et al. 2016).	Valid (Fan et al. 2017).
Marleyimyia xylocopae Marshall and Evenhuis 2015 **(Insecta: Diptera: Bombyliidae)**	Holotype captured after seven photographs by the senior author but later escaped. Paratype had previously escaped after eight photographs, prior to capture.	This paper triggered the most extensive discussion on the topic of photo-based description so far.	Valid.
Presbytis johnaspinalli Nardelli 2015 **(Mammalia: Primates: Cercopithecidae)**	Holotype and 'ten syntypes' (=paratypes) designated from five photographs 'from the internet and publications'.	Nijman (2015) claimed that the specimens are 'most likely' bleached specimens of a known langur species. Nardelli (2016) questions Nijman's reasoning and defends the status of a distinct species.	Unresolved.
Cephalodasys interinsularis Kieneke et al. 2015 **(Gastrotricha: Macrodasyida: Cephalodasyidae)**	Holotype studied alive, photographed and measured, no longer extant. Paratype preserved.	Two specimens were studied alive (one fully mature, one subadult) and a third specimen was studied after fixation and was partially damaged. 'Since only a single mature specimen was studied alive, this specimen is designated as the holotype even though it is no longer extant. [...] The specimen prepared for SEM [...] is designated as a paratype specimen' and preserved in a museum.	Valid.
Cheirogaleus andysabini Lei et al. 2015 (Mammalia: Primates: Cheirogaleidae)	Holotype captured, measured, ear biopsies and blood samples taken, microchip tagged	No explicit reason for not preserving the complete holotype is given, but prevalent habitat destruction in the area and unknown conservation status of the species is mentioned elsewhere in the paper.	Valid (Rowe 2016).
Nothybus absens Lonsdale and Marshall 2016 **(Insecta: Diptera: Nothybidae)**	Holotype escaped after photograph by the second author. No preserved parts.		Valid.
Eulophophyllum kirki Ingrisch and Riede **in** Ingrisch et al. 2016 **(Insecta: Orthoptera: Tettigoniidae)**	Holotype designated from photograph. No preserved parts.	'Unfortunately *E. kirki* sp. n. could not be collected due to strict conservation rules in the Danum Valley Conservation Area' (Ingrisch et al. 2016).	Valid.
Cheirogaleus shethi Frasier et al. 2016 (Mammalia: Primates: Cheirogaleidae)	Holotype captured, measured, ear biopsies taken, blood sampled, microchip tagged, and specimen released.	Holotype and paratypes were all released. Two older, preserved specimens were not included in the type series.	Valid.

Table 1. *Continued*

Taxon	Types	History	Current status
Microcebus ganzhorni Hotaling et al. 2016 (Mammalia: Primates: Cheirogaleidae)	Ear clip tissue sample taken. No measurements, photographs or morphological data available. Holotype is preserved genomic DNA.	A tissue sample of a released specimen, collected almost two decades ago, turned out to be genetically different from known species.	Valid.
Lepilemur otto Craul et al. 2017 (Mammalia: Primates, Lepilemuridae)	Holotypes captured, photographed, measured, ear biopsies and hair samples taken, specimens released.	No full specimens were preserved because the novelty of the species was only discovered later in the lab. It was decided not to collect a specimen of this threatened species because of conservation and permitting issues (U. Radespiel, pers. comm. 2017). The species was first described by Craul et al. (2007) and considered valid in the literature (Zinner et al. 2007, Wilmet et al. 2014, Craul and Radespiel 2016). However, as the paper was published only electronically at times when electronic publication was not permitted for nomenclatural purposes, the name was unavailable (Krell 2009) and was republished in a *Code*-compliant way by Craul et al. (2017).	Valid.
Lepilemur randrianasoloi, *Lepilemur sahamalazensis* Andriaholinirina et al. 2017 (Mammalia, Primates, Lepilemuridae)	Holotype (*L.r.*)/syntypes (*L.s.*) captured, photographed, measured, ear biopsies taken, specimens released. Tissue samples and DNA preserved	No explicit reason for not preserving the full holotype/syntypes is given in the paper, but the reasons are as above. The species were first described by Andriaholinirina et al. (2006) and considered valid in the literature (Zinner et al. 2007, Wilmet et al. 2014, Kappeler 2016, Seiler and Schwitzer 2016), However, as the paper was published only electronically at times when electronic publication was not permitted for nomenclatural purposes, the names were unavailable (Krell 2009) and were republished in a *Code*-compliant way by Andriaholinirina et al. (2017).	Valid.

- studied, photographed and released, lost or never captured type specimens (Fricke and Kacher 1982, Welch et al. 1986, Jonkers and Roersma 1990, Jones et al. 2005, Sinha et al. 2005, Mendes-Pontes et al. 2006, Robb et al. 2013, Li et al. 2015, Marshall and Evenhuis 2015, Lonsdale and Marshall 2016).
- photographs or figures and previous descriptions used by authors who have not personally studied or observed a physical specimen, in contravention of Recommendation 73B (Billberg 1833, Bock 1913, Wallach and Jones 1994, Hecq and Larsen 1998, Lowry and Springthorpe 2007, Bertagnolio and Racheli 2010, Nardelli 2015, Ingrisch et al. 2016);

The reasons, if stated, why no full specimens were preserved are

- ethical or conservation considerations (Smith et al. 1991, Jones et al. 2005, Mendes-Pontes et al. 2006, Mishra and Sinha 2008 [referring to Sinha et al. 2005], Gentile and Snell 2009, Barrera et al. 2010, Robb et al. 2013, Li et al. 2015);
- legal obstacles (Peterson 2014 [referring to Athreya 2006], Ingrisch et al. 2016);
- capture technically impossible (Frike and Kacher 1982, Robb et al. 2013); or
- escape of the specimen (Marshall and Evenhuis 2015, Lonsdale and Marshall 2016).

No Preserved Type Material at All

With the times of Linnaeus and Billberg long gone, new descriptions without any preserved type material—without any physical evidence beyond photographs—appeared again in the 1980s. The earliest example we know of is a deep water tilefish that was described by Fricke and Kacher (1982) on the basis of high-resolution footage from a submersible. Observed in depths of 80–116 m, specimens of this timid fish could not be caught. The authors were well aware that the set of morphological characters available for describing the new species was very limited as meristic characters (scale counts) could not be derived from the color slides. Indeed, when the species was used by Earle and Pyle (1997) for comparison with another new species of *Hoplolatilus*, these shortcomings became obvious. While the body color, well documented on the photographs, indicates a distinct species, morphometric and meristic characters could not be used comparatively.

While the tilefish was actually observed by the authors who extensively documented its behavior, some authors have proceeded with descriptions on the basis of photographs of specimens they have not directly examined, thus disregarding *Code* Recommendation 73B that holotypes should be specimens studied by the authors themselves.

Cryptophidion annamense, a snake from Vietnam, was described by Wallach and Jones (1994) on the basis of three almost 30-yr-old color slides. The authors published the detailed description in the journal *Cryptozoology* as they interpreted the lack of a preserved holotype as giving this species 'cryptozoic status.' Pauwels and Meirte (1996) discussed the described characters and synonymized the species with *Xenopeltis unicolor* Reinwardt, which was rebutted by Lazell (1996) and Wallach and Jones (1996). We are unsure whether the community has reached a consensus about this species. A preserved specimen, or first-hand examination of the putative species, might have helped to resolve the dispute.

In 2010, a new parrotlet from Colombia was described from a photo of over 30 caged individuals found on the webpage of a wildlife recovery center. The center was unresponsive, and the website disappeared soon (Bertagnolio and Racheli 2010). The authors decided to describe and name the new bird as *Forpus flavicollis* because of its consistent and unusual coloration and fixed 31 of the 32 specimens in the photograph as syntypes. Shortly after publication of this new species, the ICZN Secretariat was notified about the case, and Notton (2011) clarified on behalf of the Secretariat that the name was indeed available (i.e., legitimately published according to the Code). But Donegan et al. (2011) claimed that the specimens 'seem very likely to have been individuals of [the common species] Spectacled Parrotlet *Forpus conspicillatus* with certain of their feathers dyed yellow or orange.' Feather dying seems to be common in Colombia and particularly in this species. Donegan et al. synonymized the two species. With specimens at hand, the original authors might not have been fooled or might have been able to defend their interpretation if the color is natural.

The golden-crowned langur, *Presbytis johnaspinalli*, from Indonesia was described on the basis of five photographs of caged specimens that had been posted to the Internet by conservation and animal rescue organizations with very limited or no metadata (Nardelli 2015). The photos show 'one holotype and ten syntypes' (which are in fact paratypes, not syntypes), all of a distinct coloration. Later in the same year, as if the parrotlet history was repeating itself, Nijman (2015) pointed out that the new *Presbytis* species are 'most likely partially bleached Ebony Langurs, *Trachypithecus auratus*', and probably the same specimens that were confiscated from an Indonesian animal trader on the same day in 2009. Bleaching or dying mammals and birds to produce novelties for sale seems to be a common practice in Indonesian animal markets (Nijman 2015). The original author defended himself promptly, questioning the practice of artificially coloring in this case (Nardelli 2016). Subjective disagreements about species synonymy are routine even with the normal availability of type specimens, but this particular issue could probably have been easily resolved if Nardelli's description had been supported by preserved type material or at least by first-hand study of the specimens in question.

In earthworms, we have a case of a species first described in an unpublished thesis but not formally published until over two decades later, after the type was lost. Dyne and Jamieson (2004) write in the description of the new species *Diplotrema glareaphila*: 'As type specimens cannot be located, this species is erected on the illustration and account in Dyne (1984, unpublished [PhD thesis]) (ICZN 1999: Art. 73.1.4.).' Such loss or potential loss can happen, most likely after publication, but as we see, even before. The *Code* allows for such situations, as Art. 73.1.4. says: 'Designation of an illustration of a single specimen as holotype is to be treated as designation of the specimen illustrated; the fact that the specimen no longer exists of cannot be traced does not of itself invalidate the designation' (ICZN 1999).

A new *Strix* owl was described from Oman by Robb et al. (2013) on the basis of photographs and sound recordings. Comparing their photos with the poorly preserved holotype of *Strix butleri* and other specimens identified as this species, they recognized two distinct species and described one as the new species *S. omanensis*. The authors did not collect specimens because they considered the population to be small, did not want to hamper the field study of the most easily accessible specimens, and assumed that permitting would have been a problem. Two years later, Kirwan et al. (2015) recognized the same two species but considered the true *S. butleri* to be the species that Robb et al. called *S. omanensis* and considered *S. butleri* of Robb et al. to be an undescribed species. Kirwin et al. synonymized *S. omanensis* with *S. butleri* and provided a new species name for *S. butleri* sensu. Robb et al. (2016) captured a specimen of that species and collected feathers for DNA analysis, confirming Kirwan et al.'s concept of *S. butleri*. Better type material might have helped with the resolution of this problem or might have avoided it in the first place.

The most famous cases of descriptions from photos with the deliberate decision to not kill and preserve full-body type specimens are descriptions of primates. Killing monkeys or lemurs for taxonomic and nomenclatural purposes is widely considered unethical, counterproductive to conservation efforts, and is often illegal, although blood or fur samples, for example, can and in most cases do serve as type material (e.g., Thalmann and Geissmann 2005; Andriaholinirina et al. 2006; Louis et al. 2006, 2008; Zaramody et al. 2006; Craul et al. 2007; Olivieri et al. 2007; Radespiel et al. 2008, 2012; Gentile and Snell 2009; Lei et al. 2015; Frasier et al. 2016; Hotaling et al. 2016). Jones et al. (2005) did not obtain such physical evidence prior to describing the highland mangabey or kipunji, *Lophocebus kipunji,* from southern Tanzania on the basis of two photographed specimens. A year later, a specimen was found dead in the trap of a resident farmer (Davenport et al. 2006). This specimen, now preserved in a museum collection, enabled further study of the species and led to a whole slew of papers on phylogeny, morphology, and developmental biology and its transfer into a different, new genus, *Rungwecebus* (Davenport et al. 2006).

In the same year, another monkey, *Macaca munzala* was described from photographs (Sinha et al. 2005). Here, too, a specimen became available shortly after the original description but the taxonomic status of the species remains unresolved (Biswas et al. 2011).

The year after those two monkeys were described, a new species of capuchin monkey, *Cebus queirozi*, was described by Mendes Pontes et al. (2006) from a forest remnant of about 200 ha in the Atlantic forest of Brazil, 'at the very brink of extinction'. This one was captured, measured, and comprehensively photographed before its release and without any part of the type specimen preserved. The detailed description and documentation allowed de Oliveira and Langguth (2006) in the same year to determine the synonymy of *C. queirozi* with *C. flavius* (Schreber).

History repeated itself in 2015 when another monkey, *Macaca leucogenys*, was described from a large number of photographs (Li et al. 2015), and a dead specimen was found at the time of the publication of the description. In the cases of these monkeys, the descriptions all seemed a bit rushed since specimens became available very shortly after the photo-based descriptions. In case of the kipunji, the preserved specimen provided additional taxonomic insight, much as the discovery of new material routinely permits new insights into the relationships of species known only from limited or older type material. This, of course, is one of the reasons continued collection, even of named species, is such a critical aspect of taxonomy.

The above few examples from vertebrate taxonomy reflect wide variations in taxonomic judgement—similar to the range seen in the invertebrate literature—and incidentally illustrate the obvious point that vouchers or types are highly desirable. The normal course of taxonomic practice, including subsequent confirmation or subsequent synonymy of species, can proceed in the absence of type specimens just as it does with reference to type specimens of various quality. But quality preserved type material can often help in the resolution of ambiguities about species status.

How Will This Practice Affect Entomology?

The recent increase in photo-based descriptions of vertebrates is unsurprising since ethical arguments against killing and preserving organisms are much more focussed on vertebrates than invertebrates. Nevertheless, a few cases of photo-based descriptions of invertebrates exist, and one of them has triggered more debate than all other photo-based descriptions combined.

In entomology, the first 'photo-based' description without a preserved specimen seems to be that of *Bebearia banksi*, a new species of nymphalid butterfly from Ghana that was first detected on video tapes (Hecq and Larsen 1998). *Bebearia banksi* was later synonymized with *B. abesa* Hewitson, 1869 due to an initial misinterpretation of the intraspecific variation of this species (Larsen 2005). The absence of a type had no bearing on this decision.

Then the unthinkable happened: A beautiful fly from South Africa escaped after being photographed in detail, and the photographs showed that it was unequivocally a new member of a small and distinct clade. Marshall and Evenhuis (2015) decided to describe this readily diagnosable fly as a new species, *Marleyimyia xylocopae*. What is more, they were outspoken about it, discussing the issue and using some strong wording as an incentive for broader debate, while advocating for the preservation of specimens whenever possible. Broader debate they got. Starting with an opinion paper in *Systematic Entomology* authored by 14 (Santos et al. 2016), followed by a *Zootaxa* discussion paper signed by 50 authors (Amorim et al. 2016), the debate produced the *Zootaxa* paper (a petition) with the largest number of signatories so far and for the time being: 493 (Ceríaco et al. 2016), and many papers to follow. This is reminiscent of the petition by Banks et al. (1993) who collected 98 signatories from 19 countries speaking out against the descriptions of new bird species without preserved type specimens. But such petitions represent politics and opportunism, not science, and have been aptly described as 'a facade of numbers' by Warren and Bradford (2013), who point out that ganging up against unpopular research risks damaging scientific discourse and contributes little more than intimidation.

In the midst of the current debate, Lonsdale and Marshall (2016) described another distinct fly from a photograph. Their revision of the entire family Nothybidae included one distinctive species that they observed and photographed in the field but failed to collect. Faced with the decision between ignoring it, naming it informally, or giving it a proper name they chose to give it a proper name. Ingrisch et al. (2016) found themselves in a similar situation upon completion of their revision of the genus *Eulophophyllum*, a group of spectacular pink katydids, for which species defining characters are clearly visible on the photographs used in their revision. They were unable to obtain specimens of a distinctive species associated with threatened and strictly protected rainforest habitats and opted to name it using a photo as a proxy with the expressed hope that it would 'lead to further photographic and/or acoustic detections, that it will convince authorities to grant permits for collection of type material [i.e., a neotype], and that it may stimulate habitat protection measures for these enigmatic species'.

We see that taxonomic practice is and has been a continuum from the vast majority of usual descriptions of new species with preserved type material through to descriptions with living or very incomplete type material and ultimately to exceptional and rare descriptions without any preserved type material.

A Heated Debate, Triggered by a Fly or Two

Marshall and Evenhuis (2015) raised the issue of proxy types in entomology with a discussion of the pros and cons of species descriptions in the absence of preserved type specimens. Their argument that 'new species without dead bodies' are occasionally justified triggered a heated and unprecedented debate, resulting in the publication of an astonishing number of discussion and position papers, petitions, and polarized opinion pieces.

The debate started off on a collegial footing with point and counterpoint in the *Bulletin of Zoological Nomenclature* (Löbl et al. 2016, Marshall and Evenhuis 2016). Although many other issues were discussed in these papers, we think the main points/counterpoints here and in the following debate were as follows:

1. A description without a preserved type is not science versus *the description and naming of a new species represents a testable hypothesis whether or not the type is lost.*
2. Any photograph can be easily modified or misinterpreted versus *specimens can be modified or misinterpreted, too.*
3. The absence of specimens prevents the discovery of additional characters versus *more characters can be extracted from good images than from bad specimens, and in any case, the discovery of new specimens (not re-examination of the type) normally leads to the discovery of additional characters.*
4. New species without preserved types should be named informally, not with a formal binomial versus *if a species warrants naming, it warrants naming under the rules of the Code.*
5. Publications like Marshall and Evenhuis (2015) may stimulate nonexperts to describe new species based on photographed specimens (i.e., produce nuisance descriptions) versus *since the intrinsic transparency of submitted papers with descriptions that are based largely on photos will lead to an increased scrutiny by both editors and reviewers, it should instead result in a drop in published nuisance descriptions.*
6. Natural history collections will encounter further difficulties if decision-makers consider digitizing specimens to be an acceptable proxy for physical specimens versus *Marshall and Evenhuis (2015) made a strong case for collections and collecting, and the content of their paper cannot be honestly used against collection support.*

These points of disagreement include the application of the *Code* (point 4), opinions about taxonomic judgement (1, 3), and speculation about future actions by dishonest, inept, or incompetent individuals (2, 5, 6). These opinions were reiterated in a stream of papers (Amorim et al. 2016, Ceríaco et al. 2016, Cianferoni and Bartolozzi 2016, Krell et al. 2016, Pape et al. 2016, Faúndez 2017, Garraffoni and Freitas 2017, Garrouste 2017, Gutiérrez and Pine 2017, Löbl 2017, Nazari and Yanega 2017, Rogers et al. 2017, Thorpe 2017 and a whole issue of the journal *Bionomina*, see Epstein 2017). The large number of papers did not contribute anything fundamentally new to the debate but clearly demonstrate that this controversial issue is of continuing interest to many practicing taxonomists.

The New Declaration of the ICZN Containing Recommendations About Descriptions Without Preserved Specimens

The issue of nonpreserved type material is not new, and comments stating that such descriptions are available for the purposes of zoological nomenclature have been issued by the ICZN secretariat several times in the past (Wakeham-Dawson et al. 2002, Polaszek et al. 2005, Notton 2011). While these comments were in alignment with the *Code*, they were not official declarations of the ICZN, hence could be disqualified as just being 'personal opinions' (Nemésio 2009). In March 2017, the ICZN issued a *Declaration* clarifying that unpreserved or lost type specimens do not affect the availability of names (ICZN 2017a). The ICZN considered the complex history of descriptions based on illustrations, with or without preserved type specimens, and practices in zoological disciplines dealing with organisms that are difficult or impossible to preserve. The previously published opinions of the former ICZN Executive Secretaries and staff, of Donegan (2008), Marshall and Evenhuis (2016), and Pape et al. (2016) turned out to be in accordance with an official statement of the ICZN. A *Declaration* cannot make major changes to the *Code*, according to Code Art. 78.3.3. Thus the following (nonbinding) Recommendations were issued to promote good taxonomic practice:

Recommendation 73G. Specific reasons for designation of an unpreserved specimen as the name-bearing type. An author should provide detailed reasoning why at least one preserved specimen, whether a complete individual organism or a part of such an individual, was not used as the name-bearing type for the new taxon and why the formal naming of the taxon is needed at a point in time when no preserved name-bearing type will be available.

Recommendation 73H. Assertion of due diligence. When establishing a new species-group taxon without a preserved name-bearing type, steps taken by an author to capture and preserve a physical specimen of the new taxon and/or locate an existing preserved specimen in natural history collections should be recounted.

Recommendation 73I. Consultation with specialists. Before the designation of an unpreserved specimen as a name-bearing type, an author should consult with specialists in the group in question.

Recommendation 73J. Comprehensive iconography and measurements. When establishing a new species-group taxon without a preserved name-bearing type, the author should provide extensive documentation (e.g., multiple original high-resolution images, DNA sequences, etc.) of potentially diagnostic characters as completely as possible. (ICZN 2017)

The Declaration contains the following explanatory note: 'Whenever feasible, new species-group taxa should be established on the basis of at least one preserved type specimen. Additional information representing diagnostic characters (e.g., illustrations, DNA sequences, audio recording analyses, etc.) should accompany the description of a new species-group taxon whenever possible, but well-preserved biological specimens (either as complete individuals, or parts of individuals) are widely regarded as representing the most generally reliable means for establishing the biological and scientific basis for a species-group name. Establishing new species-group taxa without preserved name-bearing type material is permissible under the *Code* but is discouraged unless justified by special circumstances, such as when capture or preservation of specimens is not feasible for technical reasons or for conservation concerns, or when specimens must be destroyed to reliably diagnose a new species. While preserving a whole organism as the type specimen is preferable and encouraged, in circumstances when whole organism preservation is not feasible, a portion (or portions) of the organism sufficient to allow the new species-group taxon to be reliably diagnosed should be preserved' (ICZN 2017a).

In short: Photo-based descriptions are *Code*-compliant, but discouraged, or in the words of Marshall and Evenhuis (2015): 'Specimens are indeed the 'gold standard' for species description'. However, in cases when specimens cannot be preserved, the *Code* will not prevent taxonomy and *Code*-compliant naming to be executed. In such cases, authors of a new species or subspecies will apply taxonomic judgement on a case-by-case basis to determine how to proceed.

Taxonomic Judgement

The *Code* does not infringe on taxonomic judgment and does and will not regulate scientific reasoning and decisions. Not every taxonomist exercises good judgment all the time, as most of us know from struggles with old (and some not so old) unrecognizable descriptions and out of context names. Fortunately, however, taxonomic standards are not timeless but change with advances in the reproduction and dissemination of taxonomic information. Where once a few lines of text and an associated type were considered adequate, we now expect detailed descriptions with multiple images, careful dissections, and perhaps sequence data. But those expectations and the improving standards that lead to such expectations cannot and should not be legislated by the *Code*. We cannot, for example, dictate that every description be accompanied by a dissection, a sequence, or even a photograph because we cannot predict every circumstance under which a taxonomist might deem a description appropriate. Compression fossils, amber specimens, deep-sea organisms, endangered vertebrates, and recognizable fragments all require different sorts of taxonomic judgment under different circumstances. For example, only under very special circumstances would it be good practice to name a single species known from a fragment or badly damaged specimen, but in the context of a complete revision, a taxonomist might confidently recognize a distinctive body part as a new species that can be cast in the context of the revision. The *Code* cannot dictate what quality or quantity of evidence is enough; that is a matter of taxonomic judgment. This judgment cannot get delegated to the ICZN (as suggested by Faúndez 2017), which governs nomenclatural rules but not scientific practice.

Conclusions and Consensus

Photographs, whether they are published on social media, amateur webpages, or just shared offline can be a rich source for new discoveries. For example, a new species of green lacewing from Malaysia was discovered on Flickr; the photographer was then encouraged to search for another specimen that could be studied and preserved (Winterton et al. 2012). Film and photographic material taken in a remote location 'provided sufficient evidence to justify the collection of a type specimen' of a new titi monkey species (Wallace et al. 2006). A new mistletoe was discovered in photos compiled for an online checklist of Philippine vascular plants (Pelser and Barcelona 2013). The largest New World sundew and a pygmy devil (Tetrigidae) turned up on Facebook (Gonella et al. 2015, Skejo and Caballero 2016). Skejo and Caballero then purchased specimens from a commercial dealer and linked up with collaborators in the Philippines who collected more specimens and obtained biological data. Gonella et al. organized a collecting trip to the origin of the photograph and obtained and preserved specimens.

Sometimes efforts to collect and preserve physical specimens might be fruitless or prohibited by law, or funding cannot be found to revisit a remote region multiple times until a specimen is found or before the collecting locality has been destroyed. It is then up to the taxonomist's judgment whether to proceed with a formal description and naming without a preserved specimen. Some decide that the characters depicted in the photographs are sufficient for a formal description and naming (Hecq and Larsen 1998, Marshall and Evenhuis 2015, Ingrisch et al. 2016, Lonsdale and Marshall 2016), others decide against it (Linke 2008a,b, Edwards et al. 2009, Madika et al. 2011, van der Heyden 2015).

A major point of criticism in the current debate was the fear that encouraging photo-based descriptions by example could open the floodgates for descriptions without preserved type material (Amorim et al. 2016, Ceríaco et al. 2016, Cianferoni and Bartolozzi 2016). Not much time has passed, but so far, the feared flood of 'fast and sloppy' photo-based descriptions has not manifested itself, and we know of only four recent examples of insects described using a photo as a proxy for a lost or unpreserved type (Hecq and Larsen 1998, Marshall and Evenhuis 2015, Ingrisch et al. 2016, Lonsdale and Marshall 2016). The number and worldwide provenance of signatories of the Ceríaco et al. petition opposing photo-based descriptions indicates that many taxonomists expect that they will never need or want to describe a species using a photo as a proxy type. Nevertheless, further carefully considered descriptions based on 'proxy types' are likely to appear as some taxonomists complete revisions including species that are not represented by preserved specimens, while at the same time, most practicing taxonomists are equipped with the tools to capture more and more data from living specimens. We are, however, confident that descriptions without preserved types will be used judiciously and good taxonomic judgment will prevail.

Most participants in the recent debates agree that preserved specimens should be the rule when describing new species or subspecies. To reiterate the statement by Marshall and Evenhuis (2015): 'Not only do [specimens] allow for consideration of a full suite of characters including internal morphology, microscopic, and genetic characters, they preserve data for future access with future technologies and future questions. Specimen collections are our greatest treasure trove of biodiversity information and continued collection development must remain a priority.' Purely photo-based descriptions of new taxa of preservable animals must remain the rare exception, but they will remain admissible exceptions. We deplore growing restrictions on the collection of specimens and hope that such restrictions do not increasingly force taxonomists to rely on new technology to produce descriptions without preserved types.

Note

Frank-T. Krell is a Commissioner and Councillor of the International Commission on Zoological Nomenclature and has chaired the committee that drafted Declaration 45. The draft of the Declaration was then extensively discussed and modified by the whole Commission before it was issued.

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